UNIVERSITY OF PENNSYLVANIA

THE RANGE FOR VISUAL ATTENTION, COGNITION AND APPREHENSION

HENRY SHERMAN OBERLY

A THESIS

IN PSYCHOLOGY

PRESENTED TO THE FACULTY OF THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

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THE RANGE FOR VISUAL ATTENTION, COGNITION AND APPREHENSION

By H. Sherman Oberly, University of Pennsylvania

The range of visual attention has been given in various textbooks as the grasping of from 4 to 8 simultaneously presented objects.[1] Fernberger concludes his study on the range of visual apprehension by stating that an experiment offering but one type of verbal report to the successive exposure of visual stimuli calls for the term "range of apprehension" to cover or identify the results. He states that it would be apparently impossible to assume the threshold for apprehension at more than 6 or 8 objects. He goes further and points out a possible difference between the range of attention and the range of apprehension. It was first suggested in this paper that such results would be more reliable and practical if the statistical limen or threshold were found; the limen being the point where the stimuli were correctly apprehended with a relative frequency of 0.5.

Titchener[2] defines attention as the increase of clearness for all objects within the range—an equal clearness, or the clearness of the "upper level." The "lower level" includes those objects which are not as clear to the observer, and those which are recognized and may be included in a cognitive process. Bain[3] stated that some of the things which pass before the eye can be observed by concentrating upon one object, with the exclusion of the others. This he refers to as the "preference of attention." Sully[4] has also mentioned that "psychical phenomena present themselves in unequal degrees of definiteness or distinctness." Further on: "attention may be defined as mental activity immediately resulting in a raising in point of intensity, completeness and definiteness of certain sensations. . . . and a corresponding lowering of any other simultaneously presented sensation." These definitions apparently seem to fall in the same category as that of Titchener, emphasizing clearness and distinctness.

Dallenbach[5] came to the same conclusion that Fernberger reached after experimentation: that the experiment heretofore

[1]Cf. S. W. Fernberger, A Preliminary Study of the Range of Visual Apprehension, this Journal, 32, 1921, 121-133. The statistical results of former experiments have been summarized in this paper.

[2]E. B. Titchener, *The Psychology of Feeling and Attention*, 1908, 220 ff.

[3]A. Bain, *The Senses and the Intellect*, 1868, 558.

[4]J. Sully, *Outlines of Psychology*, 1902, 84 f.

[5]K. M. Dallenbach, Attributive vs. Cognitive Clearness, *Journ. Exp. Psychol.*, 3, 1920, 183-230.

designed to measure the range of attention has been measuring the range of apprehension. Dallenbach associates the "lower level" of clearness (which is the same as expressed by Titchener) with cognition; the "upper level" being associated with straight attention. If one should then consider the results from the point of view of only the "upper level" of clearness, one would have the true range of attention.

The purpose of this paper is to add introspective reports to an experiment which heretofore has been called a "range of attention" experiment, and by so doing, to attempt to differentiate the thresholds of attention, cognition and apprehension as defined above. The procedure follows that of Fernberger in his study of the range of visual apprehension.[6]

Preliminary Series

The preliminary series were begun in the Fall of 1922. White cards with black dots, varying in number from 4 to 15, were exposed in a Whipple Tachistoscope for an exposure approximating 40σ. This procedure was similar to that employed by Fernberger; but the subjects were required to give an introspective report of the mental processes involved in the formation of their judgments.

The introspective reports of the *O*s indicate that there are possible, and of very frequent occurrence, three conscious patterns which form the basis of the verbal report of the stimuli perceived. These three patterns were described as follows. (1) *Immediate.* All the dots were perceived in a single flash of consciousness with an equal and high degree of clearness. (2) *Grouping.* All the dots were seen in a single flash of consciousness, but, owing to different degrees of clearness, there was an attentional grouping of the stimulus dots. Both of the two conscious patterns characterized above, however, gave rise at once to the verbal report without any subsequent mediating conscious processes. (3) *Counting.* This process was different from either of the other two, inasmuch as the report was always made on the basis of some subsequent re-imaging of the stimulus material. The mediating process varied from *O* to *O* and for the same *O* from time to time. The processes consisted frequently in a visual image, the dots of which were then counted verbally; or of a verbal counting with ocular-motor fixation of the position of the dots or other similar sorts of processes. Also, all of the *O*s reported wide differences in the degree of subjective assurance with which the judgments were reported.

Arrangement of the Experiment

The experiment was conducted in the Psychological Laboratory of the University of Pennsylvania. Six *O*s were chosen from the staff of the department.

[6] *Op. cit.*, 124.

All of these *Os* had taken part in the preliminary experiments and so were familiar with the materials and methods of exposure. The *Os* were Samuel W. Fernberger, Ph.D., Karl G. Miller, Ph.D., Assistant Professors of Psychology; Sidney Sanderson, M. A., Malcolm K. Macdonald, M. A., Stanley F. Cooper, B. S., Instructors of Psychology; and John W. Cooper, A. B., Assistant in Psychology. They are hereinafter referred to as F, M, S, Mc, SC and JC respectively. F, M and Mc were highly trained in giving introspective reports; S had but little and SC and JC practically no systematic introspective experience.[7]

Five series of white cards, 87 mm. square were prepared. From 2 to 15 black dots,[8] 6.5 mm. in diam. were pasted in haphazard arrangements on the white backgrounds. All of these were exposed in rotation by means of a Whipple Tachistoscope,[9] with an exposure of 37.5σ calibrated by the tuning fork method. The photographic dark-room of the laboratory was used in order to keep the illumination on the stimulus card and the general illumination constant, the only source of illumination being that of the exposure lamp. The *O* was seated 1.9 m. from the point of fixation.

The order of the stimulus cards was different in each of the five series and in each case was arranged in haphazard fashion. After the exposure of all the cards, they were turned 90° so that the right edge of each card was now the bottom of the card for the next group of exposures. This method of rotating the cards was continued throughout the experiment. Thus, any stimulus card was seen in the same (identical) position only after each 280th exposure. In this manner, and also by starting at different places in the series, the probability of the *O* memorizing the order of the series or of his recognizing any particular card was very much reduced.

For F, M and S the stimuli of from 11 to 15 dots were eliminated after some practice, inasmuch as judgments of "I do not know" were invariably given. For F, the cards were resumed for the last 50 judgments of each stimulus, for the reason that improvement was very evident.

The final experiment was begun in May 1923, with the *Os* sitting not more than an hour for any one day. Not more than 4 sittings were arranged for any one week. The *O* was allowed to rest for a period of several minutes whenever he chose. Two hundred and fifty judgments for each number of the stimulus dots were obtained from each *O*. The observations were completed by November 1923.

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[7]I am greatly indebted to Professor Fernberger for the suggestion of this problem, for his guidance and valuable assistance in the preparation of this paper. My thanks are also due the subjects who made the experiment possible.

[8]Dennison's No. 12 Gummed Signal Marks were used.

[9]For a description of this apparatus of G. M. Whipple, *Manual of Mental and Physical Tests*, i., 1924, 264 f.

The directions which were read to the *O* at the beginning of each experimental sitting were as follows:

"You will be shown successively for a very short exposure, cards which contain a varying number of black dots on a white background. Immediately after the exposure you will report verbally:

1. the number of dots which you have apprehended;

2. the degree of assurance or certainty of your judgment, using this scale for your report:

5—if it is a 100 to 1 bet,
4—if it is a 5 to 1 bet,
3—if it is a 1 to 1 bet,
2—if it is a 1 to 5 bet,
1—guess or do not know;

3. the method of determining your report; whether by Immediate judgment, *i.e.*, ungrouped, Grouping of dots, or Counting."

Each *O* was given some practice under the new directions before any record was taken of the judgments.

It is obvious that the introspective characterizations do not correspond to the systematic categories that have appeared in the literature. It was necessary therefore to transform the results obtained into some form of systematic categories for the purpose of study and of calculation. From a study of the literature it seems that the introspective characterization which has been described above and which appears in the instructions as *immediate* corresponds exactly to one level—*Attention*, as described by Titchener. These results have therefore been calculated under this heading.

The term *Cognition* as it appears in the literature seems to be a process which is immediate but which does not imply a single level of clearness. The principal aspect which characterizes cognition is its immediacy. It will be observed that the introspective categories of *immediate* and *grouping* are both characterized by their immediacy, although the second is further characterized by different degrees of clearness which lead to an attentional grouping. The results of these two introspective categories have therefore been combined under the title of *Cognition*.

The term *Apprehension* as it appears in the literature signifies the obtaining of a knowledge of the stimulus without restriction to the mental processes underlying such knowledge. All three of the introspective categories have therefore been combined for purposes of calculation for this systematic concept. In other words, the results for both *immediate* and *grouping*, as the two ways of getting knowledge without subsequent process, have been combined with those for *counting*, which involves such a mediating process.

The results for Attention consist solely of those which were characterized as immediate by the *O*s. The results for Cognition are those which the *O* characterized as immediate *plus*

those characterized as grouping; and finally, the results for Apprehension are a combination of the results which were characterized by the *O*s under all three introspective headings. The schema given below will perhaps still further clarify this transformation of introspective characterizations into systematic categories.

Introspective Characterization	Systematic Characterization
Immediate	Attention
Grouped	Cognition
Counted	Apprehension

It was arbitrarily determined to use for purposes of calculation only those reports which were correct and which had an assurance of 5, 4 or 3. This means that the *O* was sure enough of his report to put even money on it, and this procedure eliminates the doubtful judgments. Therefore, judgments with the assurance of 2 or 1 were eliminated from the calculations. All of the *O*s (except F) worked in entire ignorance of this elimination.

The results for each of the three systematic categories were fractionated into five groups of 50 judgments for each value of the stimulus in the order taken. The calculations were made in accordance with the phi-gamma hypothesis and these calculations were simplified by the use of Urban's Tables.[10] Such a calculation yields a statistical threshold for each of our three systematic categories as well as a statistical index of precision of the results.

TABLE I—OBSERVER F

ATTENTION

	2	3	4	5	6	7	8	9	10	11	12	13	14
I	0.78	0.62	0.38	0.14	0.04								
II	0.72	0.48	0.24	0.08	0.00								
III	0.84	0.64	0.36	0.24	0.06								
IV	0.94	0.76	0.68	0.30	0.08								
V	0.90	0.68	0.46	0.14	0.00								
Ave.	**0.84**	**0.64**	**0.42**	**0.18**	**0.04**								

COGNITION

I	1.00	1.00	0.90	0.74	0.36	0.08	0.06						
II	1.00	1.00	0.96	0.66	0.34	0.02	0.00						
III	1.00	1.00	0.96	0.84	0.36	0.02	0.00						
IV	1.00	1.00	0.98	0.92	0.52	0.22	0.06						
V	1.00	1.00	1.00	0.82	0.36	0.08	0.02						
Ave.	**1.00**	**1.00**	**0.96**	**0.80**	**0.39**	**0.08**	**0.03**						

APPREHENSION

I	1.00	1.00	0.94	0.92	0.66	0.52	0.32	0.06	0.04				
II	1.00	1.00	0.98	0.92	0.82	0.52	0.42	0.18	0.08				
III	1.00	1.00	1.00	0.96	0.82	0.66	0.52	0.26	0.14				
IV	1.00	1.00	1.00	0.96	1.00	0.76	0.76	0.52	0.30				
V	1.00	1.00	1.00	1.00	0.98	0.98	0.84	0.56	0.44	0.24	0.16		
Ave.	**1.00**	**1.00**	**0.98**	**0.95**	**0.86**	**0.69**	**0.57**	**0.32**	**0.20**				

[10]F. M. Urban, Hilfstabellen für die Konstanzmethode, *Arch. f. d. ges. Psychol.*, 24, 1912, 236-243.

TABLE II—OBSERVER M

ATTENTION

	2	3	4	5	6	7	8	9	10	11	12	13	14
I	1.00	0.66	0.30	0.02									
II	1.00	0.74	0.36	0.00									
III	1.00	0.80	0.42	0.00									
IV	1.00	0.88	0.48	0.00									
V	1.00	0.94	0.82	0.18									
Ave.	**1.00**	**0.80**	**0.49**	**0.04**									

COGNITION

I	1.00	1.00	0.88	0.52	0.48	0.06	0.02	0.00					
II	1.00	1.00	0.92	0.74	0.42	0.10	0.08	0.00					
III	1.00	1.00	1.00	0.98	0.64	0.14	0.18	0.04					
IV	1.00	1.00	1.00	0.98	0.72	0.16	0.22	0.04					
V	1.00	1.00	1.00	0.96	0.88	0.32	0.20	0.02					
Ave.	**1.00**	**1.00**	**0.96**	**0.84**	**0.63**	**0.16**	**0.14**	**0.02**					

APPREHENSION

I	1.00	1.00	1.00	1.00	0.94	0.64	0.34	0.04	0.00				
II	1.00	1.00	0.98	0.96	0.82	0.70	0.60	0.14	0.00				
III	1.00	1.00	1.00	1.00	1.00	0.90	0.62	0.14	0.00				
IV	1.00	1.00	1.00	1.00	0.96	0.82	0.64	0.10	0.00				
V	1.00	1.00	1.00	0.98	0.98	0.80	0.70	0.08	0.00				
Ave.	**1.00**	**1.00**	**1.00**	**0.99**	**0.94**	**0.77**	**0.58**	**0.10**	**0.00**				

TABLE III—OBSERVER S

ATTENTION

	2	3	4	5	6	7	8	9	10	11	12	13	14
I	1.00	0.92	0.46	0.06	0.00								
II	1.00	0.90	0.38	0.00	0.00								
III	1.00	0.92	0.50	0.04	0.00								
IV	1.00	1.00	0.76	0.10	0.06								
V	1.00	1.00	0.86	0.26	0.04								
Ave.	**1.00**	**0.95**	**0.59**	**0.09**	**0.02**								

COGNITION

I	1.00	1.00	0.96	0.68	0.62	0.42	0.44	0.20	0.02				
II	1.00	1.00	0.94	0.64	0.66	0.58	0.52	0.04	0.00				
III	1.00	1.00	0.94	0.68	0.64	0.38	0.36	0.10	0.00				
IV	1.00	1.00	0.96	0.84	0.86	0.34	0.42	0.12	0.00				
V	1.00	1.00	1.00	0.92	0.86	0.54	0.50	0.16	0.00				
Ave.	**1.00**	**1.00**	**0.96**	**0.75**	**0.73**	**0.45**	**0.45**	**0.12**	**0.00**				

APPREHENSION

I	1.00	1.00	1.00	0.92	0.96	0.62	0.64	0.28	0.06				
II	1.00	1.00	1.00	1.00	0.90	0.76	0.62	0.08	0.00				
III	1.00	1.00	1.00	0.98	0.92	0.68	0.50	0.12	0.00				
IV	1.00	1.00	1.00	1.00	0.96	0.56	0.58	0.14	0.02				
V	1.00	1.00	1.00	1.00	0.96	0.76	0.62	0.18	0.00				
Ave.	**1.00**	**1.00**	**1.00**	**0.98**	**0.94**	**0.68**	**0.59**	**0.16**	**0.02**				

TABLE IV—OBSERVER Mc

ATTENTION

	2	3	4	5	6	7	8	9	10	11	12	13	14
I	0.76	0.72	0.22	0.00									
II	0.76	0.74	0.24	0.06									
III	0.72	0.80	0.34	0.20									
IV	0.72	0.82	0.28	0.20									
V	0.70	0.82	0.52	0.20									
Ave.	**0.73**	**0.78**	**0.32**	**0.13**									

COGNITION

I	1.00	0.88	0.96	0.68	0.72	0.54	0.32	0.26	0.10	0.02	0.00		
II	1.00	0.92	0.98	0.82	0.66	0.54	0.52	0.28	0.16	0.04	0.00		
III	1.00	1.00	1.00	0.90	.076	0.54	0.58	0.16	0.14	0.02	0.00		
IV	1.00	1.00	1.00	0.98	0.76	0.56	0.60	0.12	0.14	0.00	0.00		
V	1.00	1.00	1.00	0.96	0.74	0.58	0.72	0.18	0.06	0.00	0.00		
Ave.	**1.00**	**0.96**	**0.99**	**0.87**	**0.73**	**0.55**	**0.55**	**0.20**	**0.12**	**0.02**	**0.00**		

APPREHENSION

I	1.00	0.98	1.00	0.94	0.84	0.60	0.44	0.26	0.12	0.02	0.00		
II	1.00	1.00	0.98	0.98	0.72	0.58	0.54	0.30	0.16	0.04	0.00		
III	1.00	1.00	1.00	0.96	0.84	0.70	0.72	0.20	0.14	0.02	0.00		
IV	1.00	1.00	1.00	1.00	0.84	0.68	0.66	0.16	0.14	0.00	0.00		
V	1.00	1.00	1.00	0.98	0.86	0.70	0.80	0.24	0.08	0.02	0.00		
Ave.	**1.00**	**1.00**	**1.00**	**0.97**	**0.82**	**0.65**	**0.63**	**0.23**	**0.13**	**0.02**	**0.00**		

TABLE V—OBSERVER SC

ATTENTION

	2	3	4	5	6	7	8	9	10	11	12	13	14
I	1.00	0.98	0.94	0.58	0.10								
II	1.00	0.98	0.92	0.34	0.06								
III	1.00	1.00	0.96	0.48	0.10								
IV	1.00	1.00	1.00	0.62	0.16								
V			1.00	0.68	0.20								
Ave.	**1.00**	**0.99**	**0.96**	**0.54**	**0.12**								

COGNITION

I	1.00	1.00	1.00	0.96	0.82	0.52	0.54	0.16	0.06	0.02	0.00		
II	1.00	1.00	1.00	0.96	0.92	0.74	0.82	0.52	0.34	0.14	0.08		
III	1.00	1.00	1.00	1.00	0.96	0.92	0.80	0.56	0.22	0.28	0.16		
IV	1.00	1.00	1.00	1.00	1.00	0.88	0.76	0.56	0.60	0.50	0.40		
V			1.00	1.00	0.98	0.94	0.84	0.76	0.48	0.40	0.20	0.04	
Ave.	**1.00**	**1.00**	**1.00**	**0.98**	**0.94**	**0.80**	**0.75**	**0.51**	**0.34**	**0.27**	**0.17**		

APPREHENSION

I	1.00	1.00	1.00	0.98	0.94	0.68	0.70	0.16	0.08	0.02	0.00		
II	1.00	1.00	1.00	1.00	0.96	0.78	0.86	0.52	0.34	0.14	0.08		
III	1.00	1.00	1.00	1.00	0.96	0.92	0.80	0.56	0.22	0.28	0.16		
IV	1.00	1.00	1.00	1.00	1.00	0.88	0.76	0.56	0.60	0.50	0.40		
V			1.00	1.00	0.98	0.94	0.84	0.76	0.48	0.40	0.20	0.04	
Ave.	**1.00**	**1.00**	**1.00**	**1.00**	**0.97**	**0.84**	**0.79**	**0.51**	**0.34**	**0.27**	**0.17**		

TABLE VI—OBSERVER JC

ATTENTION

	2	3	4	5	6	7	8	9	10	11	12	13	14
I	0.60	0.64	0.22	0.08	0.00	0.02							
II	0.64	0.58	0.14	0.02	0.00	0.00							
III	0.76	0.62	0.38	0.00	0.00	0.00							
IV	0.80	0.68	0.60	0.00	0.02	0.00							
V	0.86	0.90	0.84	0.14	0.00	0.00							
Ave.	**0.73**	**0.68**	**0.44**	**0.05**	**0.00**	**0.00**							

COGNITION

I	1.00	1.00	0.66	0.66	0.58	0.34	0.12	0.00	0.00	0.00	0.00
II	1.00	0.98	0.54	0.54	0.58	0.14	0.00	0.00	0.00	0.00	0.00
III	1.00	0.98	0.54	0.28	0.26	0.02	0.02	0.00	0.00	0.00	0.00
IV	1.00	1.00	0.62	0.18	0.14	0.00	0.04	0.00	0.00	0.02	0.00
V	1.00	1.00	0.84	0.24	0.02	0.00	0.02	0.00	0.00	0.00	0.00
Ave.	**1.00**	**0.99**	**0.64**	**0.38**	**0.32**	**0.10**	**0.04**	**0.00**	**0.00**	**0.00**	**0.00**

APPREHENSION

I	1.00	1.00	1.00	0.98	0.86	0.80	0.52	0.04	0.04	0.00	0.00
II	1.00	1.00	0.98	1.00	0.86	0.84	0.54	0.16	0.08	0.00	0.00
III	1.00	0.98	0.94	0.94	0.96	0.92	0.44	0.08	0.00	0.00	0.00
IV	1.00	1.00	1.00	0.98	0.88	0.94	0.52	0.06	0.00	0.02	0.02
V	1.00	1.00	1.00	1.00	0.94	0.92	0.42	0.08	0.04	0.00	0.00
Ave.	**1.00**	**1.00**	**0.98**	**0.98**	**0.90**	**0.88**	**0.49**	**0.08**	**0.03**	**0.00**	**0.00**

Results

The observed relative frequencies for each O appear in Tables I to VI, one table given to the results of each subject. In the first columns are the series into which the results were fractionated. In the successive columns are the observed relative frequencies of judgments for the different stimulus values. Each table is divided into three parts,—the upper third giving the values for Attention, the middle the values for Cognition, and the lower third the values for Apprehension. The averages are given in the bottom row of each section.

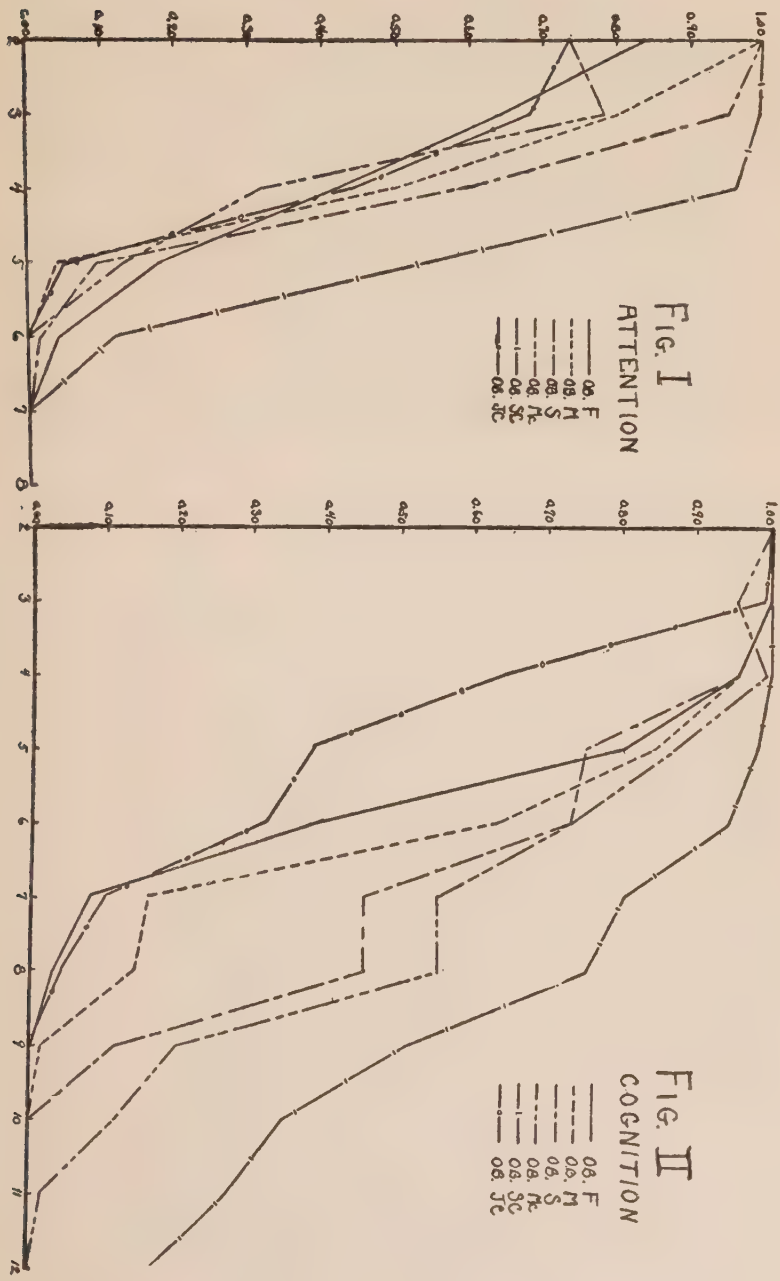


FIG. I
ATTENTION
OB. F
OB. M
OB. S
OB. Mc
OB. SC
OB. JC
FIG. II
COGNITION
OB. F
OB. M
OB. S
OB. Mc
OB. SC
OB. JC

These average results are shown in graphic form in Figg. I to III. In Fig. I the curves of the psychometric function for Attention for all 6 *O*s are superimposed. Figg. II and III are similarly constructed for Cognition and Apprehension respectively. By inspection of these curves it can readily be noted that the attention judgments are relatively similar for all of the *O*s, tending to group together, with the curves of the psychometric functions relatively steep and very similar in both form and position. In the cognition process their results are widely distributed and the curves are relatively less steep. In the third or apprehension series the results for the different *O*s tend to group together again and the curves drop more rapidly than those for cognition, once they start, but not so rapidly as the ones for attention.

In Fig. IV the curves are based on the averages of the observed relative frequencies for each *O*. In other words, the curves which are relatively similar in form are widely separated

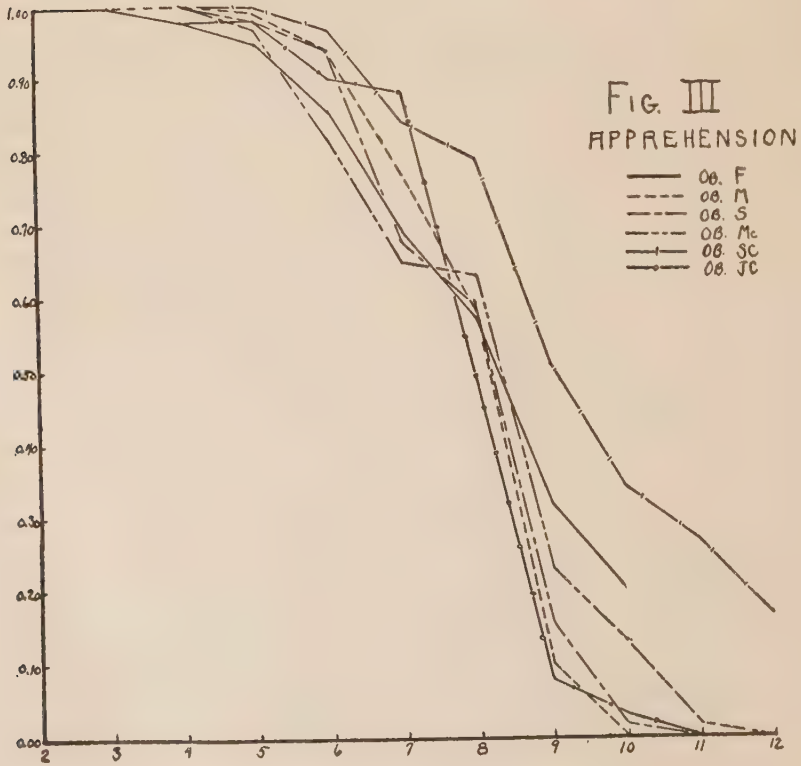
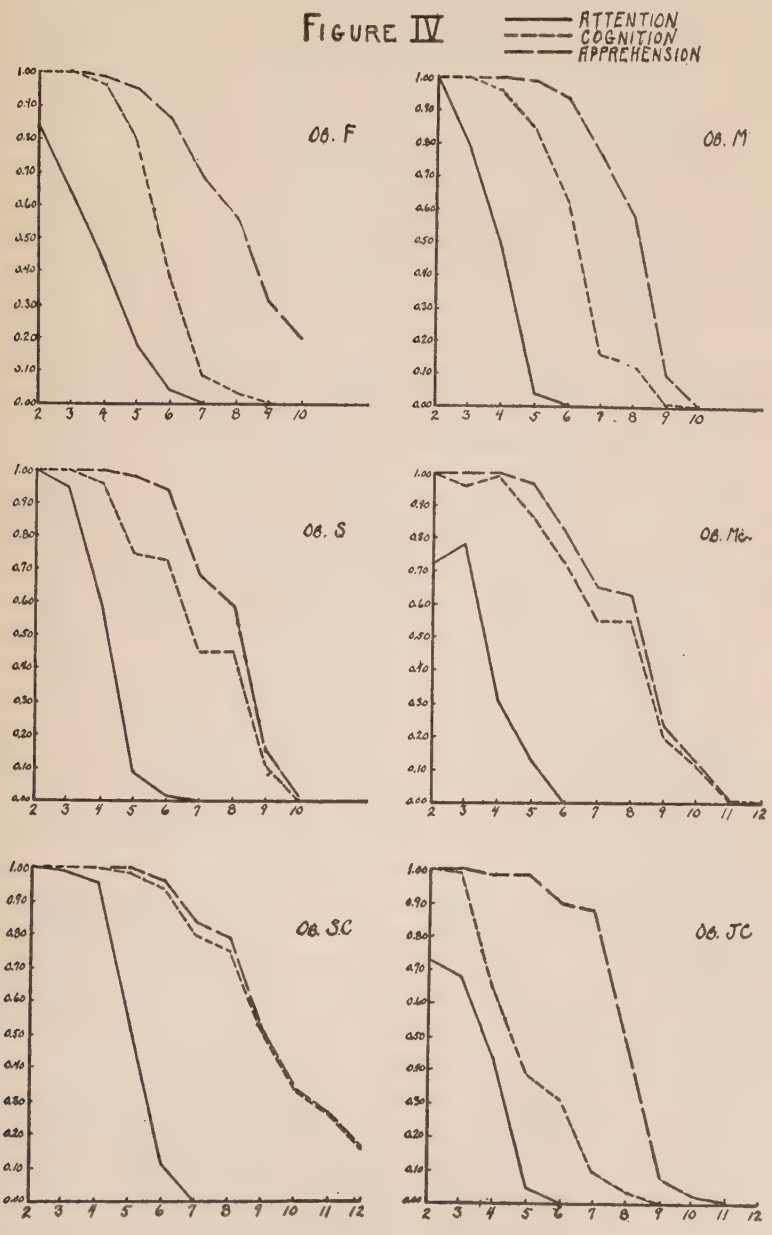


FIGURE IV


ATTENTION
COGNITION
APPREHENSION
Ob. F
Ob. M
Ob. S
Ob. Mc.
Ob. SC
Ob. JC

each from the other with relation to the abscissa. For Mc and SC the curves for cognition and for apprehension are relatively similar with regard to both form and position in relation to the abscissa. For these *O*s, however, both curves are exceedingly shifted toward the higher values from the curves for attention. The curves for S and JC have an intermediate relationship. In both cases the curves for attention and apprehension are widely separated. For JC the curve for cognition, although quite different from either of the other curves, tends more nearly to approach that of attention; for S the curve for cognition tends to approach that for apprehension.

This indicates that for all *O*s a marked difference in results was obtained between attention and apprehension. For F and M cognition was markedly different from either. For Mc and SC, cognition was markedly different from attention but not from apprehension. For S cognition was markedly different from attention, but less markedly different from apprehension; and for JC the opposite relations seem to hold.

TABLE VII—OB. F

SERIES	ATTENTION		COGNITION		APPREHENISON	
	s	h	s	h	s	h
1	3.381	0.4461	5.642	0.56011	6.957	0.41432
2	2.9028	0.46657	5.453	0.7798	7.430	0.40075
3	3.5936	0.43048	5.6712	0.87154	7.907	0.37708
4	4.2617	0.49782	6.2104	0.67397	9.0396	0.30712
5	3.7028	0.53656	6.2385	0.74927	9.753	0.37373
AVE.	**3.5684**	**0.47551**	**5.8430**	**0.72694**	**8.2173**	**0.37460**

TABLE VIII—OB. M

SERIES	ATTENTION		COGNITION		APPREHENSION	
	s	h	s	h	s	h
1	3.2175	0.8165	6.5679	0.54419	7.1625	0.63119
2	3.6548	0.6374	5.7312	0.53775	7.8265	0.41616
3	3.8242	0.6921	6.4668	0.54839	8.1632	0.82908
4	3.9643	0.84696	6.7033	0.59919	8.0343	0.67657
5	4.4256	0.95254	6.8862	0.66309	7.8942	0.60288
AVE.	**3.8173**	**0.78910**	**6.4711**	**0.57852**	**7.8161**	**0.63118**

TABLE IX—OB. S

SERIES	ATTENTION		COGNITION		APPREHENSION	
	s	h	s	h	s	h
1	3.9356	1.00562	6.8166	0.28966	7.9785	0.40806
2	3.7866	1.27356	7.1027	0.2595	7.898	0.55466
3	3.952	1.0608	6.612	0.31975	7.7342	0.55304
4	4.4299	0.89562	7.0935	0.38865	7.7152	0.55151
5	4.6765	1.10118	7.5633	0.4103	8.0746	0.57484
AVE.	**4.1561**	**1.06736**	**7.0376**	**0.33357**	**7.8801**	**0.52842**

TABLE X—OB. Mc

SERIES	ATTENTION		COGNITION		APPREHENSION	
	s	h	s	h	s	h
1	3.239	0.53834	6.926	0.26690	7.656	0.36796
2	3.2463	0.56564	7.416	0.26844	7.8378	0.31566
3	3.5433	0.38213	7.5652	0.34898	8.0724	0.40855
4	3.486	0.4038	7.6728	0.36966	7.9762	0.39329
5	3.823	0.33432	7.6633	0.37664	8.1148	0.44663
AVE.	**3.4675**	**0.44485**	**7.4487**	**0.32612**	**7.9314**	**0.38642**

TABLE XI—OB. SC

SERIES	ATTENTION		COGNITION		APPREHENSION	
	S	h	S	S	S	h
1	5.0705	0.85512	7.7375	0.42829	8.066	0.49981
2	4.7907	0.9503	9.026	0.32466	9.1652	0.36107
3	4.9495	1.09075	9.4826	0.3426	9.4826	0.3426
4	5.2291	0.90422	10.8025	0.17593	10.8025	0.17593
5	5.3538	0.87194	10.174	0.35036	10.174	0.35036
AVE.	**5.0787**	**0.93447**	**9.4445**	**0.32437**	**9.5381**	**0.34595**

TABLE XII—OB. JC

SERIES	ATTENTION		COGNITION		APPREHENSION	
	S	h	S	h	S	h
1	2.866	0.38522	5.775	0.26642	7.7536	0.54889
2	2.7664	0.52973	7.5609	0.28349	7.9504	0.40353
3	3.4722	0.3566	4.4821	0.44878	7.793	0.38594
4	3.868	0.39123	3.718	0.26116	8.0354	0.47734
5	4.3564	0.46676	4.6121	0.6023	7.8932	0.69568
AVE.	**3.4658**	**0.42591**	**5.2296**	**0.26402**	**7.8851**	**0.50228**

The calculated results for all the *O*s appear in Tables VII to XII. The first columns show the fractionated series for the results of the *O*s. The tables are divided next into three groups which indicate the systematic characterizations, Attention, Cognition and Apprehension, and these are each divided into two columns showing the value of the threshold (S) and the value of *h*, which is considered as the index of precision, for each series. The bottom row of figures in each table shows the averages for the values of S and *h* for each of the three systematic categories.

The Limens

The average value of S in the case of F (Table VII) shows a wide difference for each of the characterizations, ranging from 3.6 for attention to 5.8 for cognition to 8.2 for apprehension. JC (Table XII) is the next in rank order to show such a variation, with the changes in the value of S from 3.5 to 5.2 to 7.9. M (Table VIII) shows the variation from 3.8 to 6.5 to 7.8. Mc (Table X) shows a similar wide range of difference, from 3.5 to 7.4 to 7.9; the difference between cognition and apprehension is only 0.5. The results of S (Table IX) are very similar to those of Mc in this respect, for his value of S for attention is 4.2, for cognition is 7.0 and for apprehension 7.8; the difference between the threshold value for cognition and apprehension is but 0.8. SC (Table XI), as may be noted in the charts above, has the highest range of any of the *O*s, and his results follow the same general trend; from the value of 5.1 for attention to 9.4 for cognition, and 9.5 for apprehension. As was stated above, concerning the curves drawn from the averages of the observed relative frequencies which are shown in Fig. IV, the difference between attention and apprehension in all cases of the *O*s is marked and striking. The results of F, M and JC show

a difference in the values of S between attention and cognition, and also between cognition and apprehension. With S, Mc, and SC the difference between cognition and apprehension is much less marked.

An examination of the threshold values for the individual fractions shows that for F, M, S and Mc the relations which have been described for the averages hold throughout. There is one exception in the results for JC,—in fraction 4 the threshold for cognition is very slightly less than that for attention. For SC the values of S for fractions 3, 4 and 5 are the same for the categories of cognition and apprehension, a result which indicates that for these 3 fractions the *O* made not one single report which was characterized as counting.

Progressive Practice

An analysis of the results of the value of S for the different fractions of our *O*s from the point of view of progressive practice shows the following for attention. All of the *O*s show an increase in the size of the threshold as experimentation progressed. For M and Mc the increase was steady from fraction to fraction, amounting in the case of Mc only to 0.58, while in the case of M the increase is 1.2. For S, SC and JC there is only one inversion in the size of the threshold, and in every one of these cases the inversion occurs by the threshold in the first series being larger than that for the second (and for SC for the third also). The amount of increase for these *O*s from the first to the last series is: S, 0.74; SC, 0.28; JC, 1.49. For F an increase in the size of the S from the first to the last series is also apparent, amounting to 0.32. Two inversions are to be found in this series, however, the order of the fractions with regard to magnitude of the S being 2, 1, 3, 5, 4.

For 5 of the *O*s the thresholds of cognition also show an increase with progressive practice, the difference in the size of the first and the last thresholds being for F, 0.59; M, 0.30; S, 0.74; Mc, 0.73; SC, 3.06. The value of S for none of these *O*s shows a steady increase from fraction to fraction. The values for JC are anomalous, inasmuch as there is a decrease in the size of the threshold from the first to the last fraction of 1.17, and the order of the series with regard to magnitude is 4, 3, 5, 1, 2.

A similar increase with regard to magnitude of the threshold values for all *O*s is to be found for progressive practice in apprehension. F alone shows a systematic increase for the 5 fractions, the total amount of increase being 2.8. The amount of increase for the other *O*s is: M, 0.73; S, 0.09; Mc, 0.45; SC, 2.73; JC, 0.14. For Mc and SC only one inversion is found for the 5 individual fractions, while for the other three *O*s (M, S and JC) the order is quite irregular.

It would seem then that progressive practice has an effect of varying degree upon the different systematic categories for the *O*s who have been studied. In the case of F a large effect of progressive practice is to be found for apprehension, a considerably smaller effect for attention and cognition, although the increase for cognition is slightly greater than that for attention. For M the greatest amount of progressive practice is to be found for attention; slightly less for apprehension, and considerably less for cognition. For S there is an equally marked effect for attention and cognition, with an almost negligible effect for apprehension. For Mc the magnitude of the effect is not very different for the three categories, the order being cognition, attention and apprehension. For SC a very marked effect is found for cognition and also for apprehension, while a negligible effect only is found for attention. For JC a large effect is found for attention, a negligible effect for apprehension, and a negative effect for cognition. It seems obvious, as was also borne out by the introspection of this *O*, that the apparent negative effect of progressive practice upon cognition was really an artifact. This was brought about by the increase in training in introspection which the *O* obtained during experimentation, which led him to classify in the later experiments many of the processes under counting which had formerly been classified under grouping.

The following Table indicates the number of *O*s who showed gains in the value of S for the systematic characterizations Attention, Cognition and Apprehension. The first column shows the number of the series, and the number of *observers* listed under the following three columns indicates those whose results show an increase over the preceding series.

Series	Attention	Cognition	Apprehension	Total
2	2	4	5	11
3	6	4	4	14
4	5	5	3	13
5	5	4	3	12
Total	18	17	15	50

The possible totals under attention, cognition and apprehension are 24 each.[11] This would indicate that there are more cases of gains in attention than for cognition or apprehension. The possible totals in the last column for each series are 18 each. This indicates that the second series was the poorest for the *O*s, and it may be stated here that the longest period between any two series was between the first and the second. The third and fourth fractions were run through within a short period of time; but there is still a decrease evident. There are more variations

[11]Four series, six *O*s.

in the results for cognition and apprehension, which may account for the falling off of gains—while attention seemed to be more constant and steady. For the totals of neither columns or rows are the differences great.

Index of Precision

When one considers the average values of the index of precision (h) for the three systematic categories, the following relations seem to hold.

For M, S, Mc and SC the average value of h for attention is higher than for either of the other two; the value for apprehension is next, and that for cognition is lowest. This means that for these four *O*s the curves for the psychometric functions for attention were steepest, while those for cognition were least steep.

These relations do not hold when one considers the individual fractions into which the results of these *O*s were divided, with the exception of S, where the relations described above hold throughout. For M three exceptions are to be noted: in the second fraction the relations for cognition and apprehension are reversed; for the third fraction the h for cognition is highest; in the fifth fraction the order is: cognition highest, attention and apprehension. Two exceptions are to be noted in the values of h for Mc. In the third fraction the order is: apprehension highest, then attention and cognition. In the fifth fraction the order is: apprehension, cognition and attention. For SC in the last three fractions, attention is always highest, and the values for h for cognition and apprehension are exactly the same.

F gives values for the coefficient of precision which do not agree with the average values of the four *O*s whose results have just been analyzed. For this *O* the average values of h for cognition are highest, attention second, and apprehension lowest; and these relations hold true for every one of the five fractions into which the results were fractionated.

JC has average results which are also at variance with the first four *O*s analyzed. For him the value of h is largest for apprehension, attention second, and cognition smallest. Only two of his fractions agree with his average results, however,—namely, 1 and 4. For fraction 2 the order is attention, apprehension, cognition; for fraction 3, cognition, apprehension, attention; for fraction 5, apprehension, cognition, attention.

For the majority of the *O*s, therefore, the least precision is found with cognition. F, who has had the most experience with introspective methods, ranks high with cognition, while JC, who has had the least amount of training in the introspective method, has the lowest value of h for cognition.

Progressive Practice

The effect of progressive practice on the index of precision (h) seems to be variable from O to O. Perhaps one can best illustrate by using the following diagram; + indicating an increased effect; o, no effect; − a negative effect.

Observer	Attention	Cognition	Apprehension
F	+	o	−
M	+	+	o
S	o	+	o
Mc	−	+	+
SC	−	−	−
JC	o	o	o

Taking the algebraic sum of these symbols no effect is found for attention, a slight positive effect for cognition (+2), and a negative effect (−1) for apprehension.

Discussion

I. *Are the three systematic categories properly chosen and properly defined experimentally?* In attention, according to Titchener, the organism is interested in the object at hand. There are not active and passive states of attention, but there is one state of attention when all the organism is directed to the exposed stimulus with the exclusion of other material. In this experiment the *O*s were instructed to make a verbal report of the number of stimulus dots apprehended, and to give an introspective report as to how they determined the number of dots apprehended. The report "immediate" was to be given in this experimental procedure when there were no subsequent mental processes involved and only when all parts of the process were of an equal degree of clearness.

As this method of judging is limited in regard to the mental processes involved, there appears to be justification in calling the first of our systematic categories *attention*. It obviously agrees with the definition of attention as given by Titchener, and experimentally it has been found that the *O*s indicate this in their introspections at the completion of the experiment.

M reports: "Where an immediate judgment was reported, the dots seemed of equal clearness and definition. Introspection shows no interval between the exposure of the card and the number perception. In every case 2 dots were apprehended immediately. For the 3-dot stimulus the condition for immediate judgment demanded approximately equal spacing and not great extension. In many cases the difference between immediate and grouping judgments was determined not so much by the number of dots exposed as by the spatial arrangement.[12] Invariably immediate judgments were given with the greatest assurance. The verbal report followed the exposure with almost the speed of a simple reaction."

[12]Cf. A. M. Bowman, Size vs. Intensity as a Determinant of Attention, this JOURNAL, 31, 1920, 87-90.

S reports: "An immediate judgment was given without attention to the perseverating image, and a high degree of confidence in its correctness always accompanied it. [A "5" judgment.] This applied to numbers 2 and 3, and usually 4 which could be apprehended in a single group."

Mc reports: "In judging the number of dots a definite effort is made to group them. This makes the estimation of their number easier and more accurate. In cases where there is only one group I make a report of 'immediate'."

SC reports: "With immediate judgments I find, with the smaller groups (3, 4 and occasionally 5) there is a simultaneous and equal clarity, *i.e.*, all dots stand out clear cut and of equal blackness at one time; with the larger groups (most of the 5s, and all of the 6s) there is an *immediate consciousness* of 6—or 5, with a slightly greater clarity to a certain component (2 or 3) than to the rest, which elicits a re-reading of the memorial image—this seems to be due to the point of fixation, and varies from time to time with the same card. All immediate judgments were attended by a high degree of assurance."

JC reports: "At first the judgments reported as immediate were so in a process quite analogous to a reflex. There was no recognition in consciousness of any process except the visual, and the report was not elicited by any other element than the stimulation. That is to say, no sooner was the stimulus presented than the report was made, and an actual consciousness of the report itself, or of its nature, was not experienced until it was given."

These introspections indicate that the verbal reports of "immediate" are definitely linked with the single level of clearness which Titchener mentions. SC was one of the *O*s with practically no training in the introspective method, and his results show that he has the highest range of attention of the *O*s—and he uses the method of rechecking his results *after* he has given his report on the number of stimulus dots apprehended. Here the organism is limited, and it is noticeable in our results that there is a corresponding limited range of attention for the *O*s. A report of immediate judgment is similarly given with the grouping process, but the *O* is not limited to the single level of clearness as described above. The *O* now is permitted to use other immediate means of apprehending the number of stimulus-dots on the cards, and he brings into operation another level of clearness or mental process. The organism practically doubles the process involved in attention, and this judgment is called *cognition*, whether it consists of one level or two levels of clearness. Dallenbach[13] found in an experiment on sensory clearness that two levels were possible, and as mentioned above in the introduction, the experiment dealing with two such levels is an experiment in cognition, and not one in attention as heretofore described in the literature. That is, this dual level of clearness permits the *O* to report a greater number of stimulus-dots than he does in attention proper. Consequently, there are several attentional processes which are grouped and which are reported verbally as "grouping," and there is a corresponding increase in the range of cognition over

[13] *Op. cit.*, 230.

the range of attention. This range of *cognition* is defined experimentally in the fact that the *O*s report the grouping of the stimulus dots. Further, examine the introspection of each *O*.

M reports: "The group judgments seem to be a combination of two or more immediate judgments. The group of 3 or 4, and very rarely 5 dots was apprehended as a unit and combined with another similar group. Again the spatial arrangement of the dots seemed of primary importance; some stimulus cards which readily permitted a group judgment in one position offered a decidedly different problem when rotated through 90° or 180°. In every case where the group judgment was given it was arrived at following a definite act of addition. The two or more groups, although exposed for so short a time that eye movement was impossible, registered in a distinctly temporal series. The degree of assurance was frequently, but not necessarily great."

S: "A grouped judgment implied that it was on the basis of more than one group, *e.g.*, a 5 was apprehended as a group of 3 and a group of 2, or of 4 and 1. A larger number was often apprehended in terms of similar groups of familiar number arrangements."

Mc: "The groupings are made in a vertical direction, *i.e.*, the dots which lie under one another are put in the same group. An attempt was made to make vertical groups, and if only one group resulted an 'immediate' report was given; if several groups resulted, a 'grouped' report."

SC: "I found that, on three or four occasions, 5s were apprehended by grouping instead of immediate judgment as they usually come. One of these 5s consisted of an arrangement which grouped 3 and 2. Another came immediately in whatever arrangement or position it was exposed. This one first associated itself in my mind as a funnel, and thereafter appeared as a funnel in the other three positions." He further states: "With grouped judgments I am conscious of exploring the memorial image, each successive group being a trifle less clear than the preceding one; the degree of assurance depending, it seems, upon the clarity of the latter groups—or group."

JC: "As regards grouping judgments it can only be said that they have served as a makeshift in an attempt to observe a number of dots too great for immediate judgment. Consciously no attempt was made to group the dots; and where a grouping judgment was made, it was where the dots fell into natural groups themselves. These judgments, therefore, took on somewhat the same characteristic of the immediate judgments, except that the units were consciously compound, instead of single dots. As the experiment progressed there developed a tendency to count, even those cards on which dots were naturally grouped; and accordingly, as the *O* became efficient with practice, the number and importance of the grouping judgments were greatly decreased."

The calculation of the cognition or grouping results includes those for attention, for the organism is increasing the number of methods for determining the number of stimulus-dots. Only the correct results are calculated; hence, those immediate judgments, or attention, which have been considered, are included in the results for grouping, which is a more complex process for the organism.

The most complex method is one which permits greater freedom on the part of the *O*, and is that of *counting*. The instructions call for the number of dots which can be apprehended; therefore, the judgment in every case need not be necessarily an immediate one. There need not be equal levels of clearness—the

organism is "let go" and "runs wild"—the more that can be apprehended, the larger the range for apprehension. Fernberger[14] has so defined the range of apprehension—that there is not necessarily an immediate response on the part of the *O*, but some subsequent process may be used. The method permits any attentional report, any grouping report, and any counting—any method whatsoever in order correctly to gain a knowledge of the number of stimulus-dots. The introspections also bear this out for apprehension, as they do for attention and for cognition.

M reports: "The judgment of counting was usually based upon a rather indistinct but nevertheless usable immediate memorial image. One group of dots was apprehended immediately. During an intervening period the remaining dots were definitely counted with the assistance of implicit eye-movements of exploration. Since there was no clear image, the assurance of the counted judgments was rarely, if ever, high."

S: ". . . .in counting, either all the dots by the perseverating image are counted one by one, or a group was apprehended as a whole, and then the remaining dots were counted. For example, 8 might be taken as 5 dots, and 1, 2, 3 other dots!"

Mc: "When there are groups, but several single dots left over around the edges which do not fall into groups, I report counting."

SC, who did not use the "counting" report after the third fractionated series, reports as follows: "With counting judgments there seem to appear isolated dots that occur as images which pop out after the grouping is complete—these single dots were of less clarity of outline and blackness than the groups whose apprehension came earlier. Assurance is markedly less in these cases; the greater the number of single dots appearing after the groups, the greater the uncertainty, not only of the dots themselves, but of the group which came earlier—a sort of retroactive loss of recall."

JC: "Introspectively the general habit of observation which repetition forces upon the *O* was one of counting. Resulting in immediate judgments, a secondary process, counting, set in. The grouping judgments became broken up, and a great preponderance of counting judgments was given. In the earlier part of the experiment the attention was concentrated not deliberately, yet consciously, upon the stimulus upon which the eye first fell. Counting was impossible then, where the number of dots was at all large. Accordingly, unconsciously the habit of counting was fixed, and became first noticed when approximately half the judgments were made. The most significant introspection in this process was the original appearance of, and later loss of, negative after-images of the dots themselves. . . . . as the habit of counting became more fixed, the dependence on the after-images decreased, until no after-images at all were recognized in consciousness."

It has been shown experimentally that the systematic category of apprehension has also been properly chosen. The introspections of the *O*s indicate various methods of apprehending the number of stimulus-dots.

II. *Increase in S from attention to cognition to apprehension may be expected, as by definition they are progressively inclusive.* The foregoing definitions of *attention, cognition* and *apprehension* indicate that the organism has more liberty in the method of

[14] *Op. cit.*, 133.

determining the number of stimulus-dots: that is, attention permits an immediate report,—one level of clearness and distinctness; cognition may involve several levels of clearness which are also immediate; and apprehension permits the organism to go the limit insofar as methods are concerned,—any combination may be used. The definitions are progressively inclusive and a progression for the values of the thresholds is anticipated from attention to cognition to apprehension. Such is the case of all the *O*s in the experiment. Fig. IV serves to demonstrate this result graphically. It will be observed, as indicated before, that cognition and apprehension are the same for SC for the higher values; he learned to eliminate the counting reports, which accounts for this similarity.

III. *Size of h seems to decrease from attention to apprehension to cognition, on the whole.* An examination of the values of *h* for the three categories for four *O*s (except F and JC) shows the highest values for attention, intermediate values for apprehension, and smallest values for cognition. The order for F is cognition highest, then attention and then apprehension. For JC the order is apprehension, attention, cognition. In accordance with Boring's[15] paper on the stimulus-error, one would have expected that the order would have been attention, cognition, apprehension—inasmuch as introspectively attention is the most univocal process, while apprehension is the process most equivocally determined. The process of apprehension is a uniquely good example of the stimulus-attitude, while both attention and cognition, as defined above, may be classed under process attitude. Hence, insofar as in the case of five *O*s (F, M, S, Mc and SC) the value of *h* for attention is considerably larger than the similar value for apprehension, this hypothesis seems to be correct. The values for cognition, however, do not correspond so well with our general assumptions. In the case of F the value of *h* for cognition is higher than for the other two processes. For M, S, Mc and SC it is the smallest of the *h*-values. For the case of these last four *O*s, it may well be believed that the grouping process, which added to the immediate judgment really determines the form of the curve for the cognition category, was an intermediate sort of process on which the *O*s fell back when attention proper was not sufficient. A proper explanation for the high cognition value of F cannot be offered.

In the case of JC the size of the values of *h* for attention and for cognition corresponds exactly with the relations for the four *O*s discussed above. The high value for apprehension for this *O*, however, cannot be given adequate explanation on the basis

[15]E. G. Boring, The Stimulus-Error, this JOURNAL, 32, 1921, 449-471.

of this hypothesis. A comparison of his curves will indicate for cognition and apprehension (Figg. II and III) that, although the increase in the number of correct judgments is considerable for values up to 8 dots inclusive, there was markedly little increase above 8 dots, and hence the upper tail of his curve falls off very rapidly, giving a relatively steeper inflection to the curve as a whole.

Unfortunately there is a situation similar to, but much less equivocal than, that found by Fernberger with lifted weights.[16]

The results seem to show definitely that the curves for apprehension, which are definitely stimulus-attitude, show considerably less precision than those for attention, the most univocally determined judgments.

Conclusions

(1) The systematic categories "attention," "cognition" and "apprehension," as they appear in the literature, do not correspond with the introspective characterizations of the *O*s in this experiment.

(2) Attention may be characterized as an *immediate* process in which all sensory elements have an *equal* and high degree of clearness.

(3) Cognition may be characterized as an *immediate* process in which *either* the sensory elements have an *equal* clearness value *or* in which the sensory elements appear with *different* degrees of clearness; thus leading to an attentional grouping.

(4) Apprehension may be characterized as the obtaining of a knowledge of the stimulus in terms of *any* sort of mental process by either of the two processes described as attention or cognition, or by a *mediating* process of re-imaging the impression and of counting the elements in this image.

(5) The values of the threshold for our *O*s are greatest in magnitude for apprehension, intermediate for cognition, and smallest for attention.

(6) The values of the coefficient of precision (h) for most of the *O*s are largest for attention, intermediate for apprehension, and smallest for cognition.

(7) Progressive practice seems to affect all three systematic categories, and shows itself as an increase of the value of the threshold as practice continues. Both the absolute and relative increase varies from *O* to *O*, however, as one compares the three systematic categories.

(8) Progressive practice seems to have a variable effect on the magnitude of the coefficient of precision as one compares the values for the different categories for the different *O*s.

[16]S. W. Fernberger, An Experimental Study of the 'Stimulus Error,' *Journ. Exp. Psychol.*, 4, 1921, 63-76.